Standard Operating Procedures for UAV or Drone based Monitoring of Wildlife.

…'*Beyond pretty pictures of wildlife*'

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QUT UAV-Based Remote Sensing

Aim: Development of enabling autonomous technologies (software and hardware) for UAV based remote sensing

Team:

- Associate Professor Felipe Gonzalez –Team Leader
- 3 Research Fellows
- 5 PhD students
- 4 MER Students
- 2 Research Engineers
- 15 honour students

Two Research streams:

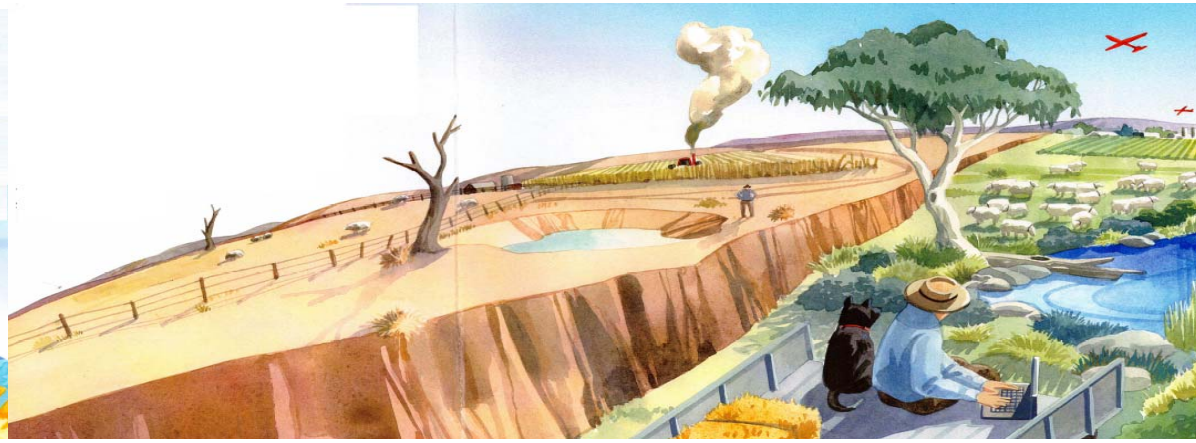
- Data collection: pure remote sensing
- **Enabling technologies**: e.g. GPS denied environment, tools, automated feature detection

Access to:

- UAV Operations team CASA UOC
- QUT Engineering Support
- Collaborative Expertise across QUT. e.g ecology, maths, statistics, geology, air quality, wildlife

Several Collaborative Projects including:

- PBCRC 2135 – wheat, myrtle rust, vineyards plant ant pest disease
- PBCRC 2164 – Chevron Buffel Grass detection
- Wildlife Detection: e.g Koala



QUT UAV-Based Remote Sensing

QUT and ARCAA Platforms Used: 1 Cessna 172, 4 DJI s800 UAV, 4 DJI F450, 3 3DR IRIS UAV, 1 Skywalker fixed wing UAV, 1 Flamingo fixed wing uav UAV, 1 Swinglet UAV





QUT Sensors Used: Headwall nano-Hyperspectral, Multispectral Tetracam Mini MCA6, MicaSense, Velodyne HDL-32E Lidar, 2 gyro stabilised Flir Tau 640 cameras, Cannon dSLR(50 MP), 1Sony Nex5, 1 multi-gas sensor system, 1 nano-particle counter, several Arduino, Odroid or Raspberry Pi Onboard Image based Decision Making payloads

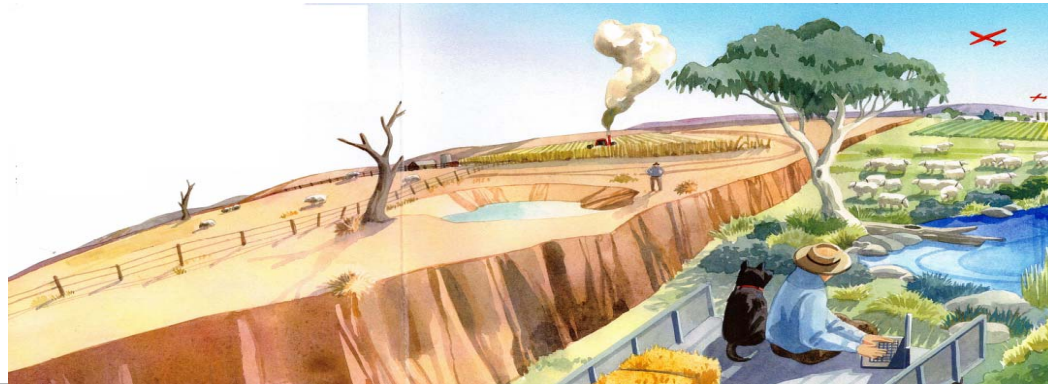








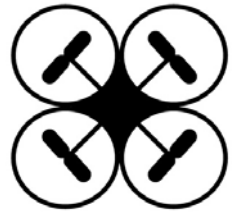
Developed Several process flows for: Multispectral, hyperspectral, digital automatic target detection, image classification and onboard decision making

Aim

- This presentation summarises a Standard Operating Procedure (SOP) and recommended practices for the use of UAVs or Drones for wildlife monitoring.

- These include some of the technological changes required to minimise impact, as well as operational considerations when deploying, surveying and recovering the UAV.



- The presentation summarises key points on the use of the Standard Operating Procedures (SOP) using a case study for the monitoring of vulnerable koala populations at four different locations in South East Queensland.

Contents

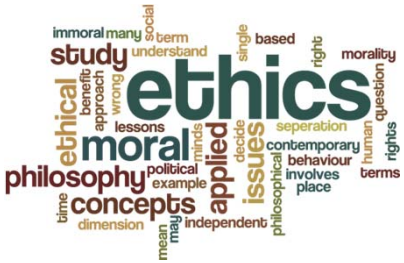
- UAVs for Wildlife Monitoring
- The Challenge
- SOP
- Our Experiments
- Results
- Conclusions

Motivation: UAVs for Wildlife Monitoring

UAVs are particularly useful for wildlife observation and monitoring as they can capture data with high spatial and temporal resolution

There is an urgent need to have standard procedures and practices in place to ensure that not only the target species, but also the unintended target species, are not adversely impacted by operating the UAV (or drone).

As outlined by Hodgson and Koh [5] different wildlife populations can respond idiosyncratically to a UAV in proximity depending on a variety of factors, including the species, environmental and historical context, as well as the type of UAV and its method of operation.



The Challenge

- Having the necessary procedures in place is a ***delicate balance*** between ethical considerations, health and safety of people, animals and property, and the objectives of the mission.
- Observation of wildlife using UAVs or drones needs to adhere to Aviation Safety Authority (e.g. CASA) rules which include among others ***restrictions*** on flying beyond visual line of sight, above a defined altitude, at night and near people or in the vicinity of important infrastructure and prohibited areas.

The Challenge(2)

Approval for flight should be sought and a procedure should not be undertaken without ***permits*** from the government, national parks, local councils or indigenous communities.

The procedure provide***s a suite of recommended procedures*** on the use of UAVs in the vicinity of animals or for the purpose of observation or surveys of wildlife.

Project Challenges

Assessing the Capabilities of Digital imaging and Unmanned Aerial Systems for Species Management: Koala Abundance

- Logan City Council, Gold Coast City Council, Tweed Shire Councils
- Collaborators: Dr. Grant Hamilton (QUT), Dr. Sandra Johnson (QUT)

Work (no flights, no data , no assessments) could proceed till Ethics approval was completed!!

STANDARD OPERATING PROCEDURE

1. Title

Observation of Wildlife using Unmanned Aerial Vehicles (UAVs) or Drones

2. Purpose

This S.O.P. details the procedures to follow for observation of wildlife using Unmanned Aerial Vehicles (UAVs) or Drones

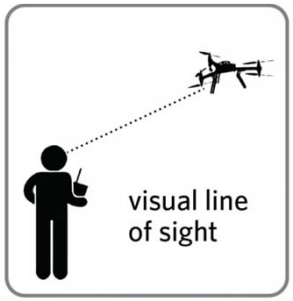
3. Scope

3.1 This procedure applies to personnel involved in the observation of wildlife using Unmanned Aerial Vehicles (UAVs) or Drones

4. Abbreviations and 5. Definitions

4. Abbreviations and Definitions

Omitted for this presentation included in the paper)



6.Training and Competency

6.1 All personnel will be competent for the procedure they perform, or be under the direct ***supervision*** of a person who is competent to perform the procedure.

6.2 When supervision is required the Chief Investigator or project lead will nominate a person competent in the procedure to be the supervisor.

6.3 People who are considered yet to be competent will be under the direct supervision of a person who is competent and a monitoring strategy will be in place until competency is attained.

6.4 ***Training records*** will be maintained by the Chief Investigator and be available for inspection by the Animal Ethics Committee on request.

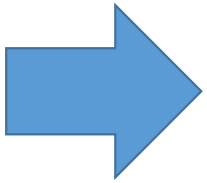
6.5 The following training and certificates are required for this SOP:

- Apply and obtain an RePL, Operator Controller certificate or similar issued by a Civil Aviation Safety Authority (e.g CASA) and if the UAV MTOW> 2.5kgs operate under a Unmanned Operator Certificate (e.g CASA.UOC).
- All personnel involved in the observational study complete and Animal Ethics course such as “Animal Ethics : The care and use of animals for scientific purposes" course[6].

Australian Government
Civil Aviation Safety Authority

7. Materials and Equipment

- UAV-
  - We evaluated the noise produced by the UAV and propellers at different altitudes and power settings in a very remote isolated area to find the UAV altitudes at witch the db level on the ground is similar to background noise.
- Thermal Camera
- Digital Camera
- FPV goggles



Defining the UAV and other equipment …more on this later

8. Safety Instructions

8.1 Apply and obtain an ***RePL, Operator Controller certificate or similar issued by a Civil Aviation Safety Authority (e.g CASA)*** and if the UAV MTOW> 2.5kgs operate under a Unmanned Operator Certificate (e.g CASA.UOC).

Note: QUT has several personnel holding a Unmanned Controller Certificate and QUT is a certified UOC operator (CASA.UOC.0466).

8.2 The UAV operators must ***adhere to aviation rules*** (e.g CASA) for the area being overflown, which may include restrictions on flying beyond visual line of sight, above a defined altitude, at night and near people or in the vicinity of important infrastructure and prohibited areas

8.3 Other personnel involved in the observation of wildlife from a UAV must ***adhere to any instructions given by the UAV controller*** to ensure the safe operation of the UAV at all times, and the minimisation of disturbance to the resident wildlife species.

Australian Government
Civil Aviation Safety Authority

8. Safety Instructions

8.4 The UAV ground station to be ***located at a reasonable distance from the survey area*** to minimise any wildlife disturbance, and if possible out of sight of the target species.

8.5 Similarly the UAV launch and recovery site must be ***chosen away from the wildlife species being observed*** and if possible out of sight of the target species.

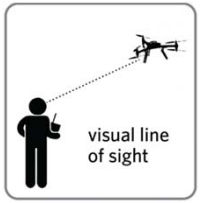
8.6 The UAV controller must have the ***ability to intervene to take manual*** control of the UAV during the flight.

8.7 If available it is recommended that at least one participant in the observational study to ***observe the visual and thermal footage from the UAV received*** at the ground station during the flight using the FPV goggles to ensure that any signs of distress or unusual behaviour by the target species are identified as early as possible so that aerial operations can immediately be suspended and appropriate action taken to minimise any stress to the animal.

9. Procedure

9.1 Define a site for UAV operations as per below

9.2 Confirm site is > 3 nm from a towered aerodrome or obtain necessary approvals



9.3 Confirm Visual Line of Sight (VLOS) with the UAV can be maintained at all times or obtain necessary approvals

9.4 Select appropriate UAV and adjust for the observational study as follows:

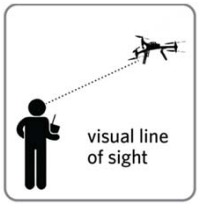
- ***Minimise the visual stimulus*** and the noise produced by the UAV as this may affect the target and non-target species,
- Reduce noise use lower RPM by adjusting the diameter and pitch of the propeller to achieve the same thrust at a lower RPM.
- ***Reduce the weight*** of the UAV to a minimum so that the amount of ***power required is at a minimum also***.

9. Procedure (2)

9.5 Select ***the right sensor and an optimal focal length*** so that it enables the accomplishment of the mission objectives while flying as far as possible from the target and not-target species.

9.6 Exercise minimum wildlife disturbance flight practices.

- Select a ***launch and recovery site away from animals*** (out of sight if possible) and maintain a reasonable distance from animals.
- Define a flight path for the UAV using the ground station ensuring the UAV is < 400 ft and that visual line of sight and video telemetry (used for observing the target wildlife species) can be maintained at all times.
- ***Avoid threatening trajectories and erratic flight movements***.



9. Procedure (3)

9.7 If practical and available use **video relay or FPV googles to observe animal responses and abort flight if unusual** behaviour or ***evidence of distress*** such as noise produced by animal or abrupt movement is observed.

- The UAV specifications and flight practices must be reported accurately and in full.
- Notes of target species responses should be included to generate an evidence base for refined SOP.
- include both ***positive and negative observations***, accidents during operations and incidents of excessive disturbances to the target species, or other species observed in the area being surveyed.
- If the negative response is observed on more than 2 occasions or it causes the animal to be at risk (eg. a koala descends tree and stays on ground) then this should be ***reported in an adverse event notification to the Animal Ethics committee***.

9.8 Once the flight path is completed, ***land the aircraft at a recovery site away from the target wildlife species*** (out of sight if possible) and maintaining a reasonable distance from the wildlife

10. Responsibilities

10.1 The CI is the person with ultimate responsibility, however individual research team members have a responsibility to ***complete the procedure(s) with due care of the animal(s) while following all instructions detailed in the SOP.***

10.2 Methods for minimising distress are as outlined in 9.1-9.8 above, and include the minimisation of noise, maintaining as large a distance as possible from the species being observed, establishing the ground station, and launch and recovery site in such a way that they minimise potential distress to the animals.

Prompt action will be taken if signs of distress are observed, and this behaviour will be documented.

10.3 The project supervisor is responsible for ensuring that staff operating the UAV are trained adequately in UAV flight operations, before they can carry out the wildlife observational flight mission.

10.4 The person/s carrying out the procedure are responsible for the welfare of the target wildlife species, and it is their responsibility to ensure correct procedures are followed, as outlined in this SOP

11.Records

11.1 The CI will maintain all records associated with these procedures.

11.2 Details of the date, location, area surveyed and the target species observed will be recorded for each flight mission.

11.3 The footage from the digital and thermal cameras will also serve as records of the observational wildlife study.

12. References

1. D. Chabot, D.M. Bird " Wildlife research and management methods in the 21st century: Where do unmanned aircraft fit in? " J. Unmanned Vehicle Systems, 3 (2015), pp. 137–155
2. A.C. Watts, J.H. Perry, S.E. Smith, M.A. Burgess, B.E. Wilkinson, Z. Szantoi, P.G. Ifju, H.F. Percival " Small unmanned aircraft systems for low-altitude aerial surveys" J. Wildlife Management, 74 (2010), pp. 1614–1619
3. K. Anderson, K.J. Gaston " Lightweight unmanned aerial vehicles will revolutionize spatial ecology" Front. Ecol. Environ., 11 (2013), pp. 138–146Australian Code for the care and use of animals for scientific purposes (8th edition, 2013).
4. J. Linchant, J. Lisein, J. Semeki, P. Lejeune, C. Vermeulen " Are unmanned aircraft systems (UASs) the future of wildlife monitoring? A review of accomplishments and challenges" Mammal Rev., 45 (2015), pp. 239–252
5. Hodgson and Koh: "Best practice for minimising unmanned aerial vehicle disturbance to wildlife in biological field research" Current Biology,
6. ARCAA Operations Manual (CASA.UOC.0466)

13. Ethics Authority

13.1 List the Ethics authority: The UAEC is the ethics authority for this SOP. The document ID, authority, approval and expiry dates are indicated in the header.

14. Risk Assessment

14.1 In addition to the SOP it is recommended and in many cases needed, to create a compressive list of identified hazards and controls and the risk assessment before controls, the type of control implemented and the risk assessment after control is implemented

Our Experiments

The experimental design of this project considered five main areas:

1. The physical design of the UAV and the sensor used
2. Sites selected for the experiment
3. Data acquisition
4. Pre-processing of information
5. the algorithms employed for detecting objects of interest and for distinguishing which category each object falls into

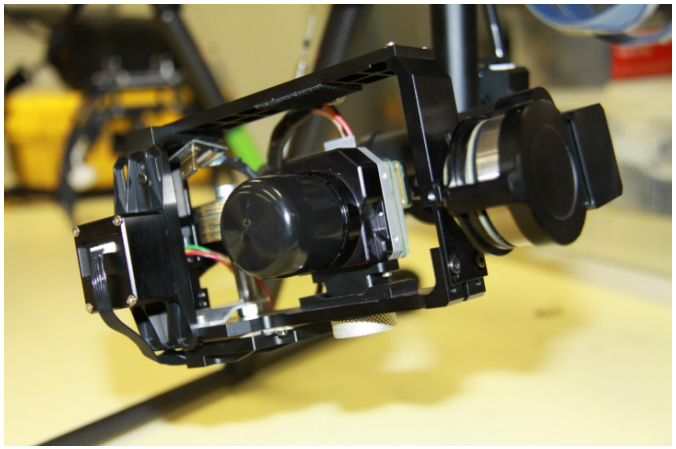
} Not discussed outside the scope of this presentation

Unmanned Aerial Vehicle (UAV)

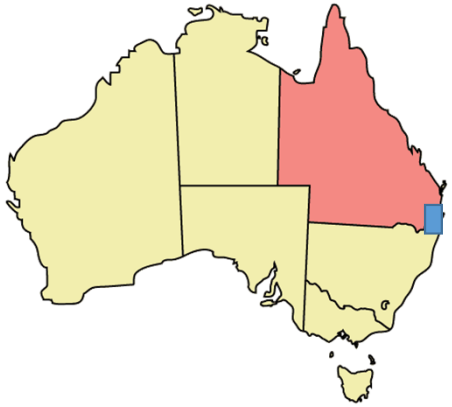
- S800 EVO Multi-rotor UAV
- Maximum take-off weight of 8kg
- 16000mAh Lipo 6 cell battery.
- Hover time of approximately 25mins with no payload
- The motor power consumption is 500W operating at 400rpm/V.
- 15x5.2inch props.
- WooKong-M (WK-M) flight controller autopilot,

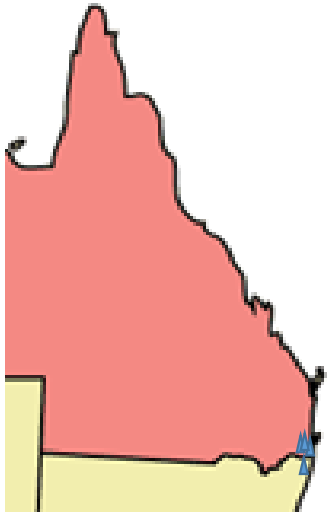
Sensors -FLIR Camera, Tau 2 640

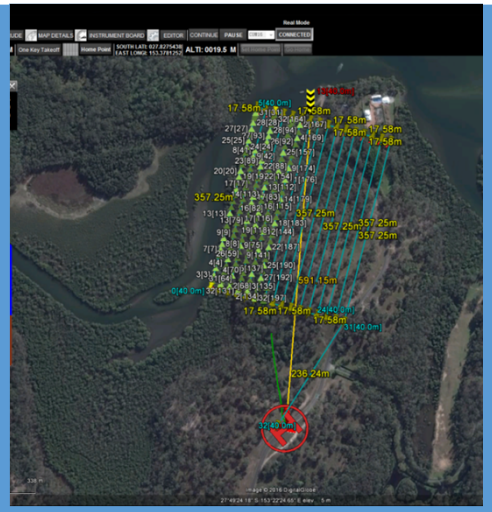
- Weight = 100g
- resolution 640 x 480 pixels
- 25mm focal lens.
- FOV 25 x 22 degrees.
- AVL58 5.8G Video Link
- Sampling frequency 9 fps,
- Sensitivity (NEdT) is <50mK at f/1.0.
- Scene range (high gain) is -25° to +135° and the low gain is -40° to +550°.
- Operating temperature of -40°C to +80° C (Flir).
- The Gimbal system Zenmuse GCU (Gimbal Control Unit).
- UAV controller to change the roll, pitch, pan, and mode of the gimbal, along with controlling the FLIR camera.



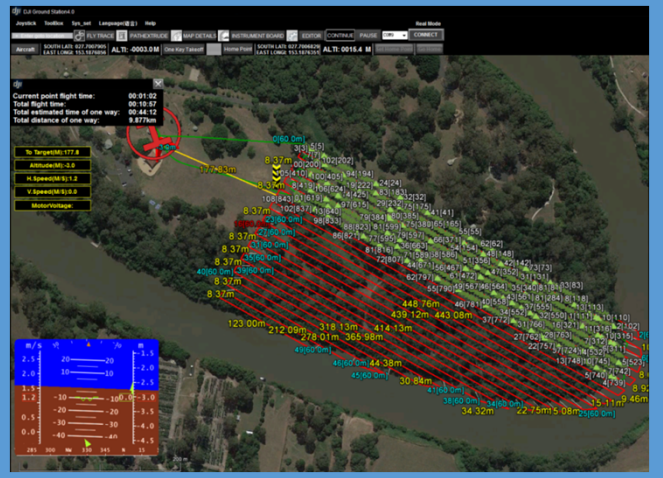
Sites





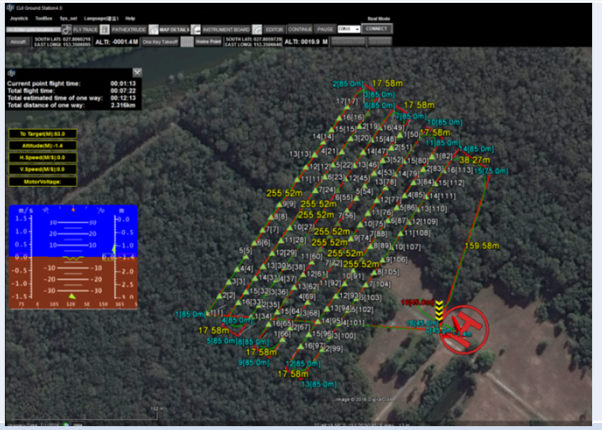


Survey Area at Colman Road Reserve, Colman Rd, Coomera



Survey Area at Alexander Clark Park. Logan

Survey Area at Black Rocks, Pottsville Tweed Shire Council



Survey Area at Pimpama Conservation area, Pimpama

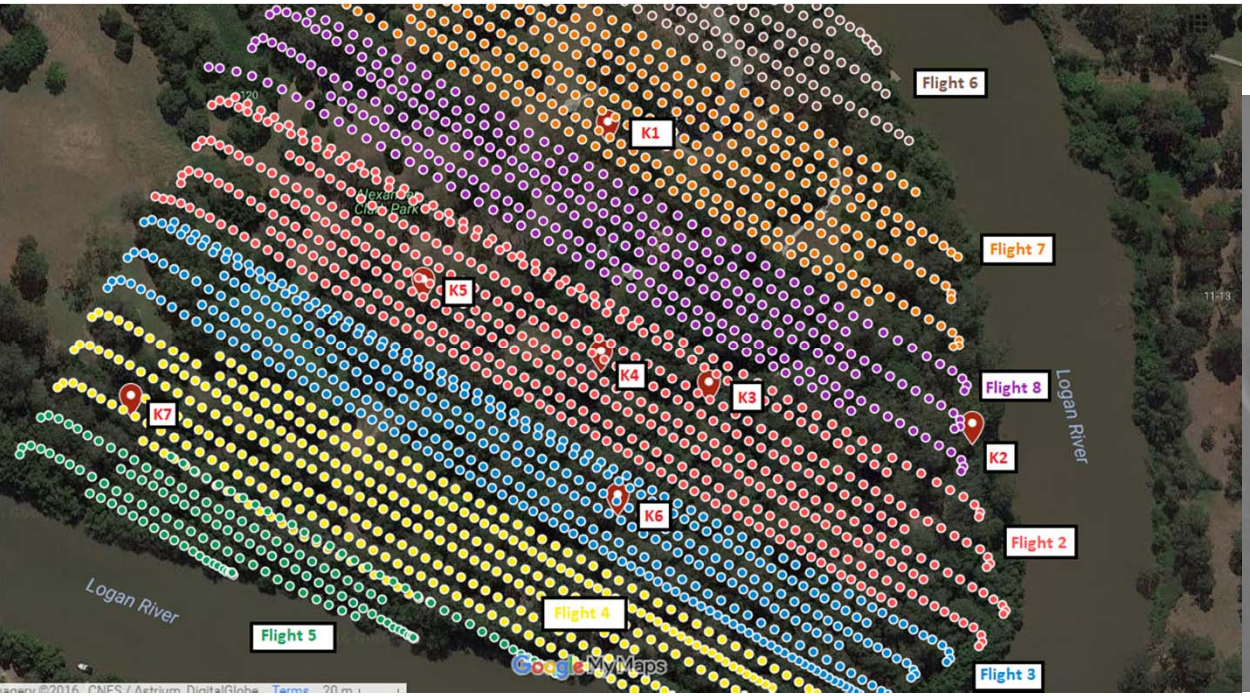
Results

Item	Procedure	Coomera	Logan
9.1	Define a site for UAV operations	As per above	As per above
9.2	Confirm site is > 3 nm from a towered aerodrome or obtain necessary approvals	Yes	Yes
9.3	Confirm Visual Line of Sight (VLOS) with the UAV can be maintained at all times	Yes	Yes'
9.4	Select appropriate UAV and adjust for the observational study as follows: • Minimise the visual stimulus and the noise produced by the UAV as this may affect the target and non-target species, subject to practical constraints. • To reduce noise use lower RPM by adjusting the diameter and pitch of the propeller to achieve the same thrust at a lower RPM. • Reduce the weight of the UAV to a minimum so that the amount of power required is at a minimum also.	Yes Yes Yes	
9.5	Optimise sensors (e.g. focal length) to enable collection of suitable data from the UAV so that it can be as high as possible, or as far away as possible, from the target species, subject to practical constraints for the purpose of the experiment, such as the quality of the collected data necessary for data analysis and detection algorithms.	Yes	Yes
9.6	Exercise minimum wildlife disturbance flight practices.		
	•Select a launch and recovery site away from animals (out of sight if possible) and maintain a reasonable distance from animals.	Yes flown 40 m to maintain LOS and safe distance	Yes flown 60 m to maintain LOS and safe distance
	• Define a flight path for the UAV using the ground station ensuring the UAV is < 400 ft and that visual line of sight and video telemetry (used for observing the target wildlife species) can be maintained at all times. • Avoid threatening approach trajectories and sporadic flight movements.	Yes No threatening approach trajectories or sporadic flight movements.	No threatening approach trajectories or sporadic flight movements.

Results(2)

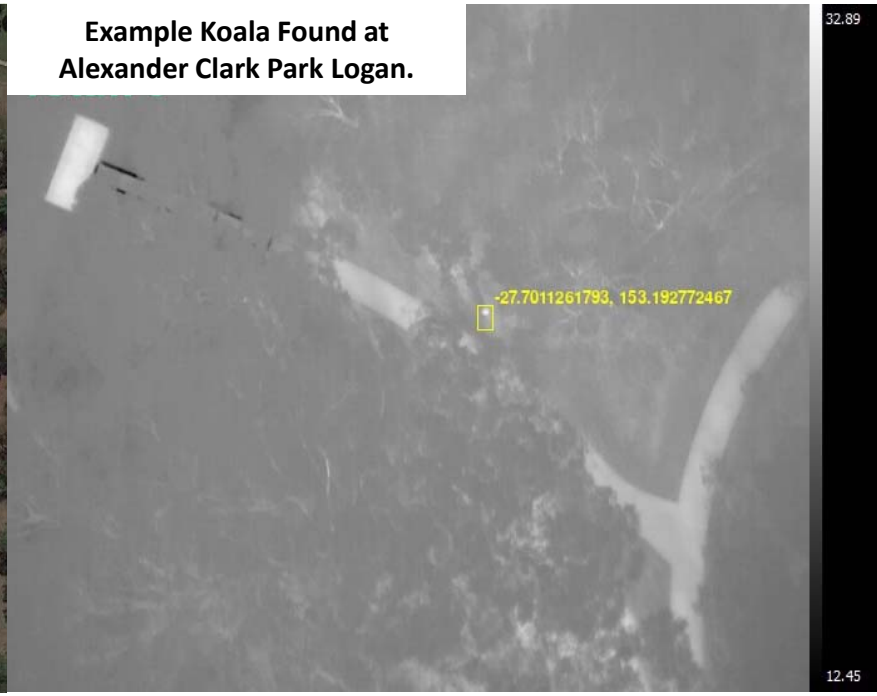
Item	Procedure	Coomera	Logan
9.7	Animal responses should be observed during UAV operations using FPV googles and aborted if unsual behavior or evidence of distress such as noise produced by animal or abrupt movement is observed.	None observed	Yes None observed
	If such disturbance is observed or suspected, the UAV must immediately be flown back for recovery.	Not observed	Not observed
	The UAV specifications and flight practices must be reported accurately and in full.	UAV specifications and flight practices reported	UAV specifications and flight practices reported
	Notes of target species responses should be included in published studies to generate an evidence base for refined guidelines.	Yes	Yes
	Importantly, the reports should include both positive and negative observations, including accidents during operations and incidents of excessive disturbances to the target species, or other species observed in the area being surveyed.	Reported no negative , no accidents no excessive disturbance	Reported no negative , no accidents no excessive disturbance
	As an example if the negative response is a once-off reaction that does not pose risk to the welfare of the animal, this would be documented in monitoring records.	Not observed	Not observed
	If the negative response is observed on more than 2 occasions or it causes the animal to be at risk (eg. a koala descends tree and stays on ground) then this should be reported in an adverse event notification to the UAEC	Not observed	Not observed
9.8	Once the flight path is completed, land the aircraft at a recovery site away from the target wildlife species (out of sight if possible) and maintaining a reasonable distance from the wildlife	Yes	Yes

Example HeatMap –Detection Results



Alexander Clark Park Flight GPS Data.

Example Koala Found at Alexander Clark Park Logan.



Conclusions

UAV at min power, slow recovery and deployment to minimise noise stimulus

Some techniques, such as ***video relay, if available shall be used to ensure that prompt action is taken*** and the UAV is either immediately landed, if safe to do so, or returned to the launch or recovery site, should any unusual animal responses indicative of distress, are observed during UAV operations.

No distress found on koalas or other wildlife

T/O and landings as per SOP

The presence of a veterinarian or suitably qualified wildlife carer may also be required, depending on the species inhabiting the target area, or any known challenges such as pregnant females, or young and vulnerable individuals.

In many cases it is sufficient that a veterinarian is aware of the UAV mission and has agreed to be contactable and able to assist in any emergency.

We ***encourage researches to use and expand on this SOP through their experiences*** and case studies and learnings for the purpose of improving the use of UAV or Drones for wildlife monitoring whilst minimising the impact to the species we seek monitor and or protect.

Thank you

Gonzalez, L.F and Johnson, S. *Standard Operating Procedures for UAV or Drone based Monitoring of Wildlife*, Proceedings of UAS4RS 2017, Hobart Function and Conference Centre (HFCC) May 24-26 , Hobart, Australia,

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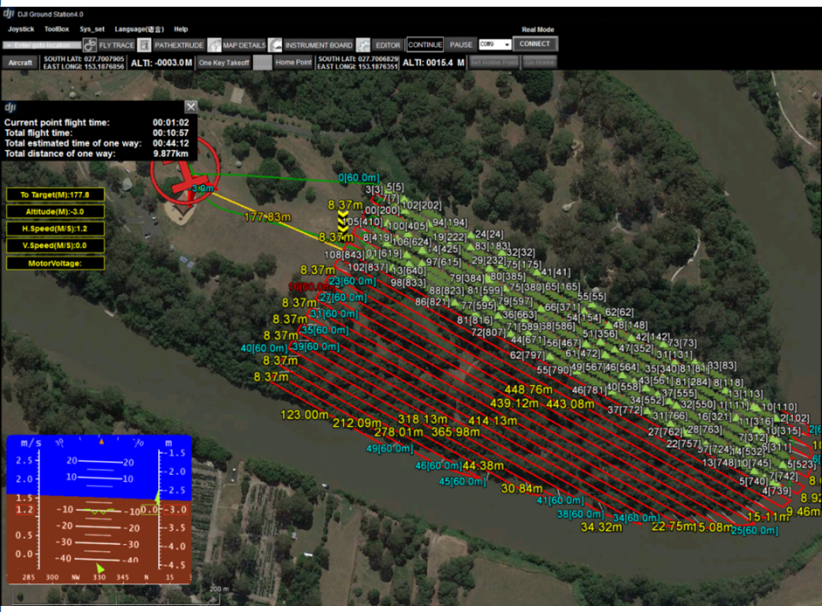
Sensors

- *Ground Control Station and Datalink :* LK900 Datalink 900MHz
- *Remote Display for Visualization:* The ground station is equipped with monitor to visualize the thermal video in real-time.
- The monitor may be used by UAV crew members, ecologists and wildlife experts to monitor aircraft motion in relation to wildlife as the UAV flies over the tree canopy

Alexander Clark Park, Loganholme, Logan City Council



Survey Area at Alexander Clark Park. Logan

Location:

- This site is located in Alexander Clark Park – 120 Dewar Drive, Loganholme
- The aerial surveys were conducted on the 4th of October 2016, between 5:50am and 9:20am and on the 20th of October 2016 between 3:53pm and 5:56pm.
- This flight was taken 60m above ground level in order to maintain line of sight with the UAV.

Flora:

- Tree height was less homogenous, as many trees were much taller than those around them, and the area was denser than Colman Road Reserve, Coomera, in parts, however all the human structures contained in the dataset breaks up the density, affording more potential to see through the treetops to lower animals, at the cost of less familiar shapes potentially affecting false detection rates.

Fauna:

- This area contained many more birds than the Colman Road Reserve, Coomera, site and a similar number of koalas, however no kangaroos or other larger animals were spotted in the videos. No fauna in Alexander Clark Park, Logan was found that humans or the algorithm could have mistaken for a koala.

Other Comments and Observations:

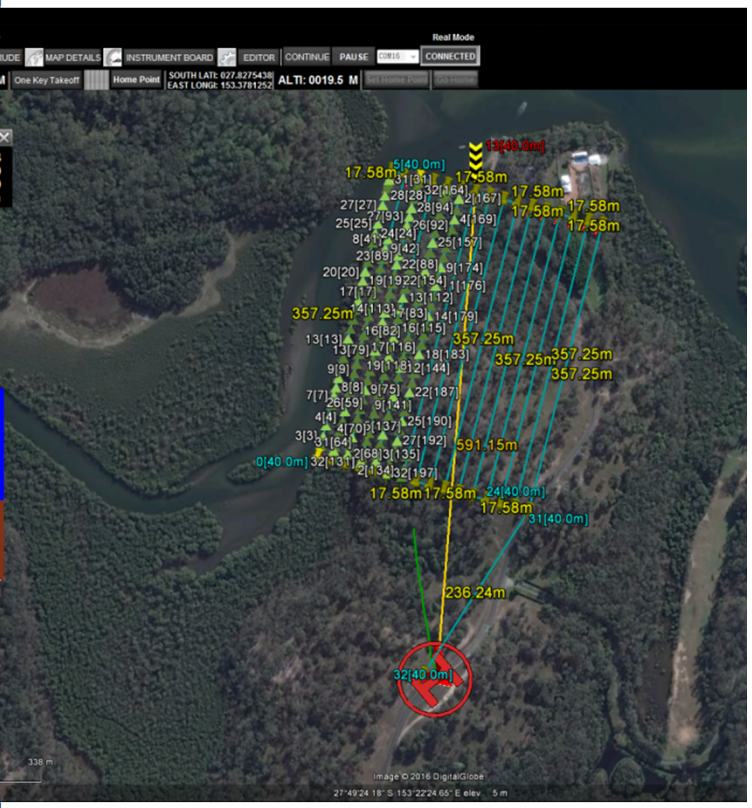
- This area is a public park with several manmade structures visible in the videos, and therefore the dataset from these flights contains footage which is less consistent and consequently more recognisable with the naked eye. A consequence of the large size of the site and increased overlap of the footage for in Alexander Clark Park, was that in order to cover it in time, the altitude was set at 60m.

UAVs for Wildlife Monitoring

- Other standard procedures include selecting the site for launching and recovering the UAV as far as practical, as agreed in consultation with wildlife experts, whilst retaining visual line of sight if this is a restriction on the UAV Operators Certificate.

- Some techniques, such as video relay, if available shall be used to ensure that prompt action is taken and the UAV is either immediately landed, if safe to do so, or returned to the launch or recovery site, should any unusual animal responses indicative of distress, are observed during UAV operations.

Survey Area at Colman Road Reserve, Colman Rd, Coomera



Survey Area at Colman Road Reserve, Colman Rd, Coomera

***Location*:**

- This site is located in Coomera, south east of Brisbane.
- The aerial survey flights were conducted on the 7th of September 2016, between 6:04am and 6:36am. This flight was taken 40m above ground level.

***Flora*:**

- Tree height was relatively homogeneous although not overwhelmingly so, as terrain height changed fairly drastically at some points in the flight.
- This generally meant that while the flight was intended to be, and is mostly, at 40m, it was also at times higher than that due to the sloping terrain.

***Fauna*:**

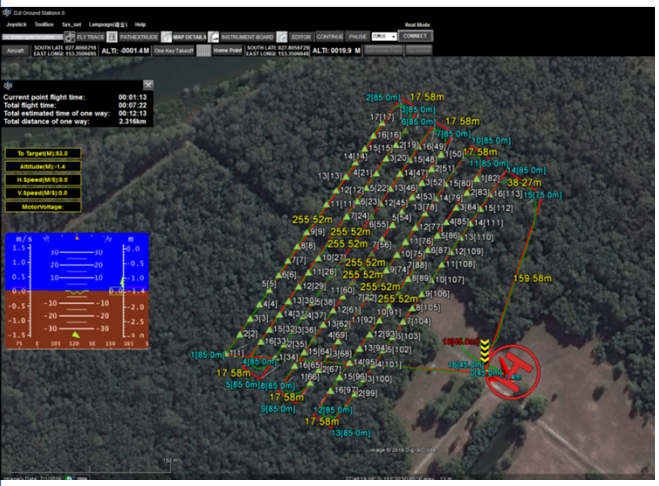
This aerial footage dataset contains birds, koalas and kangaroos.

- Kangaroos are the only species that appeared similar to koalas in shape and brightness, however being found on the ground in open areas, they are easily distinguishable from koalas due to the context of the sighting.

Other Comments and Observations:

- Colman Road Reserve, Coomera is a rather remote location with almost no unnatural structures in the target area.
- Through analysis of the videos, it can be determined that this area is not particularly dense, which allows easier line of sight between the camera and koalas below the canopy.
- Throughout the flight, there was a high temperature difference with coolest and hottest temperatures at any given point were 12 and 25 degrees Celsius, respectively. This presents challenges to the algorithms

Pimpama Conservation Area, Pimpama, Gold Coast City Council



Survey Area at Pimpama Conservation area, Pimpama

Location:

- This site is located in Pimpama, south east of Brisbane. The aerial surveys were taken on the 19th of October 2016, between 5:18am and 7:02am.
- Two flights to complete the aerial survey with 75% Latitudinal overlap, 45m above ground level.

Flora:

- Tree height is very homogeneous, and vegetation at Pimpama Conservation Area, Pimpama is very dense.
- Therefore, the canopy is difficult to see through with the thermal camera, which makes koalas that are located lower in trees, as well as other animals, more difficult to detect.
- Particularly the top-down angle of the flights is made difficult by the Pimpama Conservation Area, Pimpama vegetation, and the only success found in detections was during the ascent for the flights, where a lower angle was taken on the area.

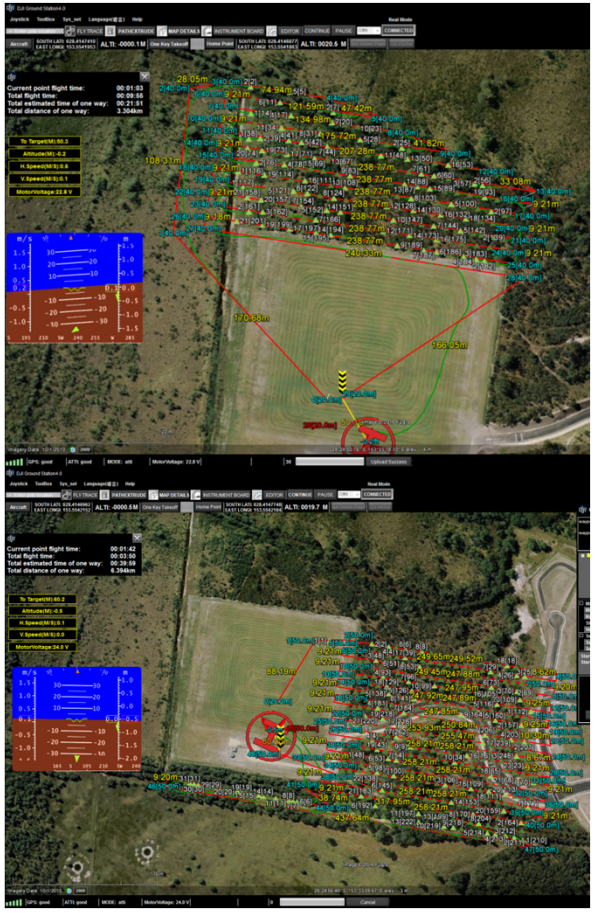
Fauna:

- This area contained very few hot spots of any kind.
- This can partially be attributed to the inability to see lower animals due to the dense tree coverage, but also the lack of birds appears to indicate a less inhabited area for wildlife in general. No fauna in this dataset looked comparable to a koala and very little of the fauna appeared similarly bright either, indicating that the potential for false detections here are low.

***Other Comments and Observations*:**

- Pimpama Conservation Area, Pimpam*a is* a very homogeneous location, which means that false positives are less likely.
- The main drawback is the thick vegetation making koalas that are sitting well below the tree canopy more difficult to see, combined with the relatively sparse wildlife present, which makes detections very infrequent.
- The potential benefits are that, in a situation like Pimpama Conservation Area, Pimpama, denser trees heighten the disconnect between koalas that are more visible in ground based surveys vs those koalas that are more visible in aerial surveys.

Black Rocks, Pottsville Shire Council



Survey Area at Black Rocks, Pottsville Tweed Shire Council

***Location*:**

- This site is located in Pottsville, south east of Brisbane.
- The aerial survey was conducted on the 6th December 2016, between 6:00pm and 8:00pm.
- This flight was taken 45m above ground level.

Flora:

- There is an interesting aspect to the vegetation of this dataset, which had an effect on the detection rate, in that some of the trees in this area do not retain heat and appear to remain cool instead.
- This dataset is very comparable to Pimpama Conservation Area, Pimpama in that vegetation is rather dense with trees at a consistent height.

Fauna:

- Similar to Pimpama Conservation Area, Pimpama, a few hot spots were noticeable in the afternoon dataset.
- Birds and koalas are present in this dataset, both in slightly greater numbers than Pimpama but less so than at Colman Road Reserve, Coomera or in Alexander Clark Park, Logan.
- No fauna in this dataset looked comparable to a koala in size, shape or temperature.

Other Comments and Observations:

- The main detractor for the Black Rocks datasets is that there is no morning flight by the time of writing this report.
- The Black Rocks dataset appears similar to Pimpama Conservation Area, Pimpama in that there is little potential for false detections due to a fairly homogeneous area.
- The difficulty to see through the canopy makes it more likely that some koalas detected during the ground survey would be challenging to observe from the aerial footage.
- On the other hand, koalas located high in trees are more likely to be missed by the ground survey team.